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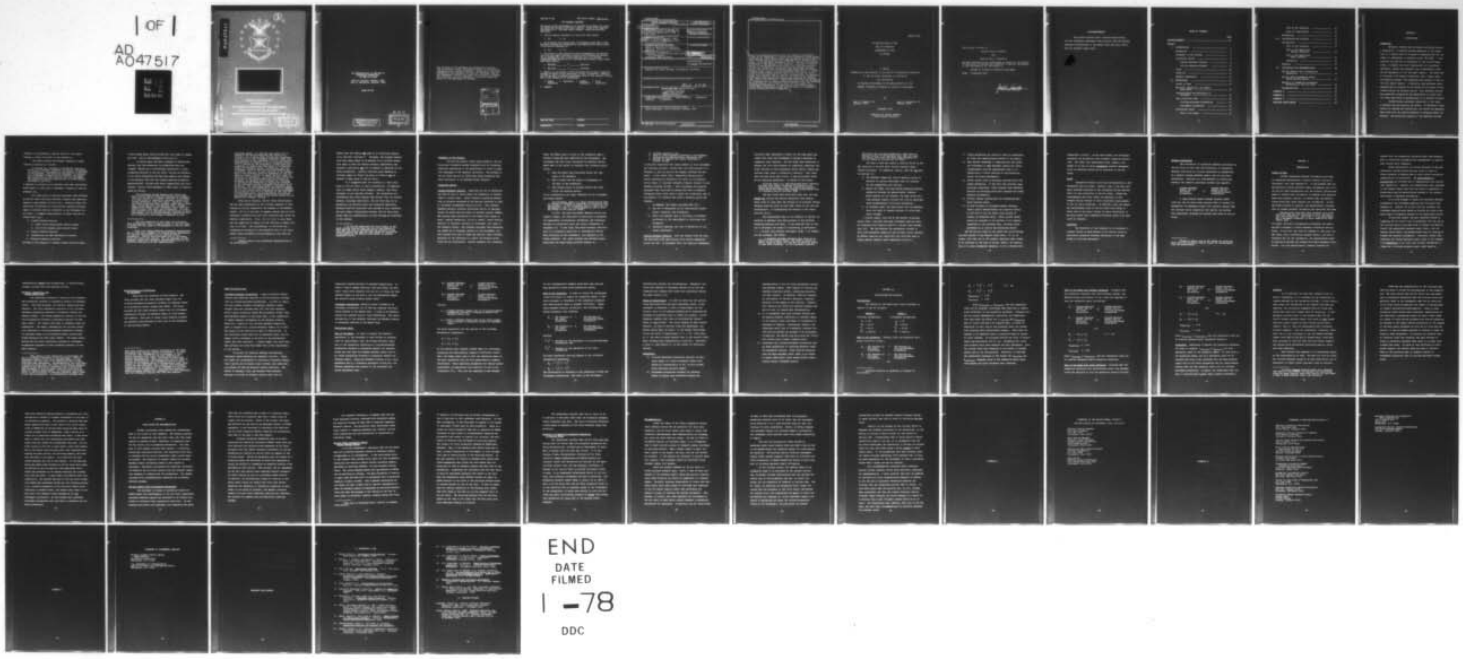

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UNITED STATES AIR FORCE
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Wright-Patterson Air Force Base, Ohio

AN INVESTIGATION OF THE USE OF AUTOMOBILE WARRANTIES IN THE AIR FORCE

Paul S. Arneson, Captain, USAF
Carl F. Barchfeld, Captain, USAF

LSSR 28-77B

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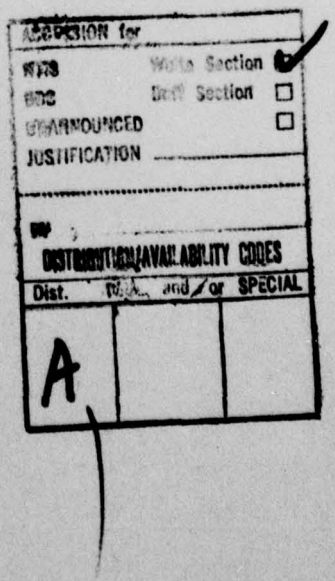

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While the warranties provided with the commercial automobiles bought by the Department of Defense offer potentially large repair cost savings, little research has been documented on the extent to which the DOD has actually taken advantage of the warranty provisions. The researchers maintained that the DOD does not exercise warranties to the maximum extent possible. Limiting its investigation to the United States Air Force, this study was conducted to test the researchers' hypothesis that the average warranty repair cost of Air Force automobiles was higher than the average warranty repair cost of civilian-purchased automobiles. A significantly higher average warranty repair cost for the Air Force would have indicated that it returns its automobiles for generally higher cost warranty repairs than the civilian sector suggesting that smaller and perhaps less significant problems are ignored more often by the Air Force. Statistical tests were run on samples of Government and civilian-purchased automobiles that had undergone warranty repairs, the results of which did not support the researchers' hypothesis. An improved Air Force vehicle repair record keeping system and a more economic method of disposing of retired automobiles were recommended.

LSSR 28-77B

AN INVESTIGATION OF THE USE OF AUTOMOBILE WARRANTIES IN THE AIR FORCE

A Thesis

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Logistics Management

By

Paul S. Arneson, BA
Captain, USAF

Carl F. Barchfeld, BS
Captain, USAF

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and

Captain Carl F. Barchfeld

has been accepted by the undersigned on behalf of the faculty of the School of Systems and Logistics in partial fulfillment of the requirements for the degree of

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CHAPTER I

INTRODUCTION

Background

Webster's Seventh New Collegiate Dictionary defines a warranty as, "a usually written guarantee of the integrity of a product and of the maker's responsibility for the repair or replacement of defective parts [16:1004]." Considering the wide use of warranties in the United States today, it appears that such "guarantees" are considered desirable. Before the extensive use of warranties, there was an atmosphere of "let the buyer beware." The buyer had no recourse if he bought a defective item. Today, under the warranty concept, the atmosphere has changed to that of "let the seller beware." A defective item purchased under warranty may be returned to the seller if the defect is discovered during the warranty period. This warranty concept has apparently perpetuated the manufacture of higher quality items than would be manufactured if no warranty existed.

Besides being considered beneficial to the buyer, a warranty can also protect the seller. To maintain a reputation for honesty and credibility, the seller has generally been faced with the implied warranty of standing behind his product. The advent and success of the expressed written

warranty is undoubtedly a partial result of the seller wishing to limit the extent of his guarantee.

The Armed Services Procurement Regulation (ASPR) defines a warranty as follows:

> A warranty is a promise or affirmation given by a seller to a purchaser regarding the nature, usefulness, or condition of the supplies or performance of services to be furnished. The principle purposes of a warranty in a Government contract are to delineate the rights and obligations of the contractor and the Government for defective items and services and to foster quality performance [14:1-5] .

A warranty so defined is no different than what individuals would expect if they were to purchase a commercial item for personal use.

One large group of products purchased under warranty by the Air Force are motor vehicles, ranging from executive sedans to road graders (13:5-1,5-10). Technical Order (TO) 36A-1-1301 (13:Section II) lists several hundred different types of vehicles that are currently in use throughout the Air Force. A summary categorization of these vehicles is listed below (11):

1. General Purpose Vehicles
   a. under 10,000 pounds gross vehicle weight
   b. over 10,000 pounds gross vehicle weight
2. Special Purpose Vehicles
3. Construction and Base Maintenance Vehicles
4. Materials Handling Vehicles

Included in the category of General Purpose Vehicles under

10,000 pounds gross vehicle weight are five types of sedans and four types of stationwagons (13:5-1,5-2).*

In recent years the basic concepts of vehicle warranties, and thus warranties on automobiles have not changed. Except for a few necessary provisions to cover situations peculiar to the Air Force, the new car warranty of Air Force automobiles has been and remains very similar to the warranty that the four leading American automobile manufacturers** provide with their commercially sold automobiles. The Air Force warranty on these types of vehicles reads as follows:

> The contractor hereby warrants the vehicle and parts thereof against defective material and workmanship for a period of 12 months from date of acceptance or 12,000 miles of operations, whichever occurs first (except batteries, tires and tubes). Warranty covers the engine block and head, integral engine parts, water pump, intake manifold, transmission case, internal transmission parts, torque converter, drive shaft universal joints, rear axle, and differential. On vehicles procured F.O.B. destination and delivered by driveaway method, the 12,000 mile warranty limitations will be in addition to the mileage accumulated by such

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*For the remainder of this study the collective term "automobiles" will be used to refer to the five types of sedans and four types of stationwagons in the Air Force inventory.

**The four leading American automobile manufacturers are (1) Ford Motor Company, (2) General Motors Corporation, (3) Chrysler Corporation, and (4) American Motors Corporation. The Air Force purchases all of its automobiles from these four sources. For the remainder of this proposal, these four automobile manufacturers will be collectively referred to as the "manufacturers."

> driveaway method. On vehicles used within the 50 states of the United States and the District of Columbia, the warranty shall include the furnishing, without cost to the Government (including labor cost when approved by the contractor), F.O.B. contractor's nearest dealer or branch, or to the original destination if desired by the Government, of new parts and assemblies to replace any that prove to be defective within the warranty period. In addition, when the Government elects to have the work performed by the contractor, the cost of labor involved in the replacement of the defective parts or assemblies at the contractor's plant, branch, or dealer facility shall be borne by the contractor. On vehicles used outside the 50 states of the United States and the District of Columbia, the warranty shall include the furnishing of new parts and assemblies to replace any returned to the contractor by the Government which prove to be defective. The replacement parts or assemblies shall be delivered by the contractor to the port of embarkation in the United States designated by the Government. The contractor shall not be required to bear the cost of labor involved in correcting defects in vehicles used outside the 50 states of the United States and the District of Columbia [12:5-6] .

With such a warranty, the Air Force theoretically has the same opportunity as the civilian community to have automobile defects repaired at the expense of the manufacturers. But it is not hard to imagine reasons why Air Force automobile operators and motor pool employees may ignore the warranty opportunity. First, the Air Force in many cases has the capability to repair its own vehicles at onbase service facilities. The inconvenience of delivering and returning an automobile to the dealer* as well as the potentially longer automobile out-of-commission time when the

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*Dealer refers to an authorized representative of the manufacturer.

dealer does the repairs may seem to be convincing reasons to do the work "in-house."* Secondly, the economic motivation that seems likely to be present for a civilian automobile owner to have his vehicle running, upholstered, and painted to perfection may not be present in operators of Air Force automobiles. Defects corrected under warranty by civilian owners to insure top price at trade-in may be ignored in many cases in the Air Force.

It is suggested that the existence of these attitudes in the Air Force is only a possibility. An appreciation for human nature would suggest, however, that their existence is not terribly unlikely. The researchers are undertaking this study because they believe that for several reasons, including those above, the Air Force may not be maximizing its benefits under the automobile warranties. Warranty benefits constitute cost savings in most instances, and with today's inflationary economy, the Air Force must insure that all opportunities for such savings are exploited to the fullest.

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* TO 36-1-42 authorizes Air Force repair of warranty covered vehicles when the cost of the repairs is less than the cost of transporting the vehicles to and from the dealers and when the time needed for correction of the defect by the dealers would result in mission impairment (12:3).

Statement of the Problem

As with any product bought under warranty, the Air Force must ultimately assume responsibility for returning defective automobiles to the manufacturer in order to take full advantage of the warranty provisions. The problem is the Air Force may not be exercising these automobile warranty provisions to the maximum extent possible.

Literature Review

General warranty research. Improving the use of warranties has been an area of study within the Department of Defense (DOD) in recent years. Thesis research concerning warranties on products purchased by the DOD was conducted in 1974 at the Naval Postgraduate School (8:1,2). This research analyzed warranty problems identified earlier in hearings before the Armed Services Board of Contract Appeals (ASBCA). The problem areas delineated in the thesis were burden of proof, implied warranties, notice of breach, latent defects, duration of warranty, warranty by Government, and scope of the warranty clause. The research indicated that warranties can indeed be of financial benefit to the Government, but that extreme care must be taken and specific rules followed precisely by the Government to insure the warranty provisions are not invalidated. Several examples were presented

where the ASBCA ruled in favor of the contractor when a warranty claim had been submitted by the Government. The Government has been found ineligible for warranty settlements when it has failed to establish the following points (8:21):

1. That the defect was discovered within the time limit of the warranty.
2. That a defect was the result of negligence on the part of the contractor.
3. That proper notice of alleged defects was given within the warranty period.

In his conclusion on the topic "Warranty by the Government" the author stated:

> The Government takes on a large responsibility when it promises to respond to conditions in connection with the contract. If the Government does not carry out its obligations, there is a high probability that it will pay highly in the long run [8:48] .

In 1975, the Army Procurement Research Office published a report, the objectives of which were to determine the appropriate circumstances, procedures, and techniques required to effectively price and enforce warranties on equipment (2). It was found that while warranty effectiveness is by necessity predicated on thorough and precise data collection by the Government, this approach is not widely observed. The report alleged that warranty provisions were not being widely enforced because of:

1. Untimely testing or use.
2. Lack of field personnel knowledge of the warranty provisions and administrative procedures; and
3. Failure of complete and timely reporting of defects [2:130] .

It was also discovered that large numbers of both Government and industry personnel contend that the effectiveness of a warranty is only as good as the company offering the warranty. It was stated that, "Repetitive dealing with a source possessing a reputation for pride in its products and an image of corporate integrity normally results in good warranty programs [2:130] ." Both Government and industry personnel were described as having felt that a reputable contractor would often honor a claim for a defective item in the absence of a warranty and after a warranty period had expired.

In summary, the report concluded that (2):

1. The use of warranties is not sufficiently coordinated, evaluated, and documented.
2. There is a general lack of tailoring of warranty provisions to the requirements of individual procurements.
3. Generally speaking, the cost of warranties is not easily determined.

Vehicle warranty research. Only two studies could be located that dealt more specifically with vehicle warranties within the DOD. In September 1974, the Logistics Management

Institute (LMI) published a report for the Army which concluded that there are advantages to having a warranty on commercial type vehicles. The LMI study team endeavored to examine the cost effectiveness of supporting commercial tactical vehicles in the Continental United States (CONUS) and overseas areas under a contractor's warranty. They found that the Army would save little, if any, procurement money by not obtaining warranties. As stated in the report:

> Although there is a cost associated with a warranty and that cost could, in theory, be avoided by not obtaining warranties, there are reasons why manufacturers would not reduce their prices substantially even if a warranty was not provided [6:9] .

LMI also found that there were times when the Army should not utilize the vehicle warranties they possess. Those would be times when the savings to be realized through warranty exercise would be more than offset by the cost and inconvenience of transporting the vehicle to the repair facility (6:11).

LMI acknowledged that in its endeavor to explore the question of warranty cost effectiveness it had problems obtaining warranty cost data. It was admitted that in trying to determine the extent of utilization of warranties, ". . . we were only slightly successful [6:4] ." As reasons for the problems, LMI stated:

> . . . a warranty provides generally that there be no charge to the vehicle owner. The owner's concern is that a fault be fixed, not how much he saved by having it done under warranty. In the Government agencies

with which LMI discussed warranties, there were no central records of the warranty work done let alone work which could have been done under warranty but for one reason or another was not [6:4] .

The lack of data was indeed a limiting factor in the LMI study and is an area where further research seems vitally necessary. To summarize, however, what LMI was able to conclude (6):

1. The standard commercial vehicle warranty should be modified to provide additional time for vehicles not put immediately into service.
2. Within the CONUS, the Army should generally exercise warranties through the manufacturers' dealers. Where dealers are not present, the Army should perform warranty repairs in-house and receive parts and labor reimbursements (bill-back agreements).
3. In overseas areas, the Army should give the manufacturer the right to examine failures to verify warranty coverage.

A second report, this one by the General Accounting Office (GAO), disclosed that many Government agencies were not obtaining full benefits available through truck warranties (15). The GAO examined the maintenance records of over 2,000 warranted commercial and military trucks operated by Federal agencies and identified five principle ways to obtain greater benefits under warranties (15:i-ii):

1. Obtain warranties for trucks at least as beneficial as those that manufacturers provide to the public.
2. Take greater advantage of opportunities that allow the Government to make warranty repairs and obtain reimbursement from the manufacturer when it is impractical to return vehicles to the authorized dealer (bill-back agreements).
3. Better inform users of military vehicles about component warranties. It was felt that military organizations especially, could increase their warranty benefits by providing users with complete and timely warranty information.
4. Provide clearer instructions for determining warranty starting dates.
5. Be more diligent in informing central warranty repair points (Warner-Robins Air Logistics Center in the case of the Air Force) with reports of repairs on warranted parts. These central repair points are supposed to be notified of all repairs, regardless of who performs them, including those performed at no cost by the authorized dealer.

The GAO did not state in its report why its investigation was limited to the Federal truck fleet. It is, of course, true that one of the primary conditions that needed to be corrected in the case of trucks, namely, the acquisition of a public-comparable warranty, is not a problem with

automobiles (13:5-6). As has been stated, the Government purchases its automobiles with standard commercial warranties. The other four improvement areas, however, all appear to be ones in which automobile warranty management could be evaluated against as an extension of the GAO study.

Scope

Documented research involving the warranties on DOD automobiles was not found. However, some of the same warranty problems described in the Literature Review possibly exist for new automobiles in the Air Force. Sedans and stationwagons have been chosen for analysis in this research mainly because of their relatively large numbers in the Air Force inventory. In addition, since the sedans and stationwagons sold to the Air Force are similar to those sold to the public except for minor variations, it was anticipated that comparative warranty repair cost data could be obtained.

Objective

The objective of this research is to determine if evidence exists to show whether or not the Air Force is exercising automobile warranty provisions to the same extent as civilian purchasers.

Research Hypothesis

The utilization of automobile warranty provisions by the Air Force is less than the utilization of automobile warranty provisions by civilian purchasers as exemplified by a greater average warranty repair cost for Air Force automobiles. Depicted in a form amenable to statistical analysis the research hypothesis becomes (see page 20):

Average Warranty Repair Cost of Air Force Automobiles	$>$	Average Warranty Repair Cost of Civilian-Purchased Automobiles.

A significantly higher average warranty repair cost* for the Air Force would indicate that it returns its automobiles for generally higher cost warranty repairs than the civilian sector suggesting that smaller and perhaps less significant problems are ignored more often by the Air Force.

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*Warranty repair cost is the charge for parts and labor that the automobile dealer claims for reimbursement from the manufacturer.

CHAPTER II

METHODOLOGY

Source of Data

Letters requesting warranty information were sent to automobile manufacturer's district service offices in Cincinnati, Ohio (See Appendix A). It was assumed that the manufacturers compile warranty repair information for civilian and Air Force automobiles, and the district offices were asked to furnish that information in whatever form possible. There were reasons, however, to believe that the manufacturers would deny these requests for information. In the LMI study referred to earlier, the manufacturers' willingness to release warranty information was described this way:

> Manufacturers know what their warranty cost experience has been but were unwilling to give the Army or LMI that information. They view it to be proprietary and a necessary ingredient in their competitive strategies [6:3].

Of course, the exact circumstances surrounding the Army's and LMI's attempts to secure warranty information was not known. It was felt that with the passage of time since the LMI study, with a differently phrased request, and with a different use for the information, the manufacturers might be willing to provide the authors with their warranty information. All four manufacturers, however, refused our

request with the explanation typically given that warranty data is restricted information and unreleasable to individuals outside their companies.

Being unsuccessful in a direct petition to the manufacturers, another method that was tried in order to obtain warranty information was to write private automotive organizations for assistance. The Encyclopedia of Associations was surveyed and 12 organizations were queried (See Appendix B). However, all organizations that responded to the request stated that they too found it impossible to secure data from the manufacturers because of the proprietary nature of warranty information.

In a third attempt to obtain the necessary warranty information, two Government agencies were solicited (See Appendix C). However, as in the first two attempts, the Government agencies were unable to provide any type of warranty repair information because of its proprietary nature.

As has been stated, the most desirable method of comparing the Air Force's use of warranties with the use by the civilian sector would have been to analyze the manufacturers' own comparative warranty repair costs. But for reasons stated above, the manufacturers were not willing to release any warranty information. Therefore, rather than analyzing the average warranty repair costs of the comparative populations of Air Force and civilian automobiles, a comparison of average warranty repair costs based on

representative samples was accomplished. A detailed methodology involved with this approach follows.

Universe, Population, and Sample Description

The underlying universe of concern in this research was automobiles returned to automobile dealers for warranty repair. From this universe, two specific populations were analyzed. The first population consisted of all civilian-purchased automobiles returned to automobile dealers for warranty repair. The second population consisted of all Air Force automobiles returned to automobile dealers for warranty repair. Two samples were used to represent these two populations. The sample representing the civilian population consisted of civilian-purchased automobiles returned for warranty repair to an automobile dealer located near Wright-Patterson Air Force Base (WPAFB). The sample representing the Air Force population consisted of Government automobiles* returned to local automobile dealers for warranty repairs.

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*The intent of this thesis was to investigate the use of automobile warranties in the Air Force. However, obtaining a sample of Air Force warranty repairs of any meaningful size was found to be impractical due to logistical and time constraints. Wright-Patterson Air Force Base, a relatively large base, has only a few automobile warranty repairs in any given year, indicating that it would have been necessary to solicit nearly every Air Force base in order to obtain a large sample. To complicate this alternative is the difficulty in obtaining warranty repair costs on Air Force automobiles. An investigation revealed that

Identification and Definition of Variables

There were two variables in this research. The first variable was the total warranty repair cost for civilian-purchased automobiles returned for warranty repair to an automobile dealer located near WPAFB. The second variable was the total warranty repair cost for Government automobiles returned for warranty repair to local automobile dealers. Both sets of repair costs analyzed included all warranty work performed on each trip of the automobile to the servicing dealer.

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base motor pools do not receive information on the costs associated with warranty repairs from dealers. In order to retrieve that information it is necessary to first obtain from motor pool files the data regarding the dealers performing the repair, the dates of repair and vehicle identification. Each dealer must then be asked to furnish the historical cost information from his files. Because of the impracticality of accomplishing these tasks within the time available, this research used Government automobiles in the Dayton area to represent the Air Force population (See assumptions.) This procedure enabled a direct-to-dealer request for information on costs associated with the Government vehicles that they had repaired.

Data Collection Plan

Civilian-purchased automobiles. A major automobile dealer located near WPAFB was selected to provide warranty information on civilian-purchased automobiles. In order to obtain the most current warranty information, warranty repair records from only calendar year (CY) 1976 were examined. Since a major automobile dealer may accomplish several thousand warranty repairs in any given year, it was impractical to obtain warranty information on all warranty repairs. Therefore, a sample of 201 civilian warranty repairs was used to represent all civilian warranty repairs in CY 1976. The figure 201 was selected for ease of calculations. In the statistical tests that will be explained later, the 201 sample points correlated to an entry in the mathematical tables that were available. A larger sample size would have been possible but would have added very little significance to the results.

To account for possible seasonal fluctuations, stratified random sampling was employed (7:53-60). Using the figure 201 corresponded to selecting 17 warranty repairs from 9 months and 16 repairs from 3 months, each month having between 217 and 284 warranty repairs available. The months of February, July, and December were randomly selected to provide 16 warranty repairs each, and the

remaining 9 months provided 17 warranty repairs each. In order to have a random selection from each month, the warranty repairs were numbered from one to n (n being the last warranty repair in the month), and the appropriate sample was selected using a random number table.

Government automobiles. Warranty repair information on Government automobiles for CY 1976 was obtained from automobile dealers in the Dayton area. A total of 31 warranty repairs was obtained from 17 local dealerships. The search included all of the probable locations for warranty repairs of Government vehicles in the Dayton area.

Statistical Tests

Test of the means. In order to support the Research Hypothesis, it was necessary to show (within an accepted level of significance) that the average warranty repair cost of the population consisting of civilian-purchased automobiles returned to automobile dealers for warranty repair was less than the average warranty repair cost of Air Force automobiles returned to automobile dealers for warranty repair. Using the standard notation of H_o = null hypothesis and H_1 = alternate hypothesis (4:330,331), the Research Hypothesis was reduced to the following one-tailed hypothesis test:

H_o : Average Warranty Repair Cost of Air Force Automobiles $\leq$ Average Warranty Repair Cost of Civilian-Purchased Automobiles

H_1 : Average Warranty Repair Cost of Air Force Automobiles $>$ Average Warranty Repair Cost of Civilian-Purchased Automobiles

Letting:

μ_1 = Average warranty repair cost of civilian-purchased automobiles returned to automobile dealers for warranty repair, and

μ_2 = Average warranty repair cost of Air Force automobiles returned to automobile dealers for warranty repair,

the above hypothesis test was reduced to the following mathematical expression:

$$H_o : \mu_2 \leq \mu_1$$

$$H_1 : \mu_2 > \mu_1$$

By the Central Limit Theorem, sample means for underlying population are approximately normally distributed (4:240). Thus, the sample means used to test the population means in the above hypothesis test are also approximately normally distributed. Since population parameters are unknown and/or unavailable, an appropriate test statistic to use is the t-statistic (17). This test was employed to show whether

the two representative samples could have come from the same population within given probability limits.

Test of the variances. In order to select the appropriate t-test with which to compare the population means, it was first necessary to determine if the population variances were statistically equal or unequal (4:450-453). Again, using standard notation (4:330,331), the following two-tailed hypothesis test resulted:

H_o :	The Variance of Air Force Automobiles	=	The Variance of Civilian-Purchased Automobiles
H_1 :	The Variance of Air Force Automobiles	$\neq$	The Variance of Civilian-Purchased Automobiles

Letting:

σ_1^2 = Variance of the population of civilian-purchased automobiles, and

σ_2^2 = Variance of the population of Air Force automobiles

the above hypothesis test was reduced to the following mathematical expression:

$$H_o : \sigma_2^2 = \sigma_1^2$$

$$H_1 : \sigma_2^2 \neq \sigma_1^2$$

The distribution of variances of any population follows the Chi-Square distribution. The ratio of two Chi-Square

distributions defines the F-distribution. Therefore, the F-test was employed to determine whether or not the two representative samples were drawn from populations having the same variance (17).

Level of significance. In order to carry out the calculations associated with the above hypothesis tests, it was necessary to establish a level of significance for the results, which is the maximum probability of rejecting the alternative hypothesis when it should be accepted. Little guidance, however, was found on selecting the "proper" level of significance. The choice depends on many diverse factors. In lieu of specific rules and guidelines, one author states that, in effect, it has become conventional to let the level of significance (α) = .05. This value of α has been so widely adopted that it has become a standard, allowing easy communication (1:190,191). Therefore, a level of significance of .05 was chosen for hypothesis testing.

Assumptions

1. Civilian-purchased automobiles returned for warranty repair to a major automobile dealer near WPAFB are representative of all civilian automobiles requiring warranty repair.
2. Government automobiles returned for warranty repair to Dayton area automobile dealers are

representative of all Air Force automobiles receiving warranty repair. Both classes of vehicles are standard production models, possessing basically the same options. In addition, both are operated by individuals not having a personal, financial interest in the upkeep of the vehicles. Finally, both vehicles are driven for business purposes and are not used for family-type transportation.

3. It is recognized that many external factors such as varying climatic conditions in different parts of the country could contribute to differences in frequency of repairs. Considering, however, the relatively short life of a warranty, external factors such as weather are assumed to be negligible. In addition, the period from which data was collected covered only a single climatic cycle.
4. Government and civilian-purchased automobiles have an equal probability of requiring warranty repair for mechanical failure. Since both are produced from the same assembly lines, there is no reason to expect that defect rates should differ significantly within a warranty period.

CHAPTER III

CALCULATIONS AND ANALYSIS

Calculations

The results of the statistical tests discussed in chapter II are as follows:*

Sample 1 (Civilian automobiles)	Sample 2 (Government automobiles)
$n_1 = 201$	$n_2 = 31$
$\bar{x}_1 = 31.71$	$\bar{x}_2 = 45.10$
$s_1 = 52.53$	$s_2 = 67.18$
$s_1^2 = 2759.72$	$s_2^2 = 4513.15$

Test of the variances. Testing first the population variances (4:450-453; 9:464):

H_o : The Variance of Air Force Automobiles = The Variance of Civilian-Purchased Automobiles

H_1 : The Variance of Air Force Automobiles $\neq$ The Variance of Civilian-Purchased Automobiles

-or-

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*Standard notation as explained in Chapter II is utilized.

$H_o : \sigma_2^2 = \sigma_1^2 \qquad \alpha = .05$

$H_1 : \sigma_2^2 = \sigma_1^2$

$F_{statistic} = 1.63$

$F_{critical} = 1.64$

Since $F_{statistic} < F_{critical}$, the null hypothesis could not be rejected, concluding that there was no statistical difference in the population variances. Although this was the correct mathematical conclusion, the researchers felt that since the values for $F_{critical}$ and $F_{statistic}$ were so close (1.64 and 1.63 respectively), it would be beneficial to also look at the situation where the population variances were statistically unequal. There were two reasons to be skeptical about a conclusion based on values so close together. As discussed earlier the level of significance was arbitrarily set at .05. Increasing this value just slightly would have rejected the null hypothesis. Also, the outcome could vary depending on the number of decimal places used in the calculations. Therefore, to overcome the undesirable closeness of the values for $F_{critical}$ and $F_{statistic}$, separate tests of the population means using both unequal and equal variances were conducted.

Test of the means with unequal variances. Assuming that the population variances were statistically unequal, the Behrens-Fisher modification of the t-test was employed to test the population means (10:334-336).

H_o : Average Warranty Repair Cost of Air Force Automobiles $\leq$ Average Warranty Repair Cost of Civilian-Purchased Automobiles

H_1 : Average Warranty Repair Cost of Air Force Automobiles $>$ Average Warranty Repair Cost of Civilian-Purchased Automobiles

-or-

$H_o : \mu_2 \leq \mu_1$ $\quad \alpha = .05$

$H_1 : \mu_2 > \mu_1$

$t_{statistic} = 1.06$

$t_{critical} = 1.68$

Since $t_{critical} > t_{statistic}$, the null hypothesis could not be rejected assuming unequal population variances.

Test of the means with equal variances. Assuming that the population variances were statistically equal, the standard t-test was employed to test the population means (3:330-331).

H_o : Average Warranty Repair Cost of Air Force Automobiles $\leq$ Average Warranty Repair Cost of Civilian-Purchased Automobiles

H_1 : Average Warranty Repair Cost of Air Force Automobiles $>$ Average Warranty Repair Cost of Civilian-Purchased Automobiles

-or-

$H_o : \mu_2 \leq \mu_1$ $\quad \alpha = .05$

$H_1 : \mu_2 > \mu_1$

$t_{statistic} = 1.27$

$t_{critical} = 1.64$

Since $t_{critical} > t_{statistic}$, the null hypothesis could not be rejected assuming equal population variances.

Conclusion. Regardless of whether the population variances are equal or unequal, $t_{critical} > t_{statistic}$ for both hypothesis tests of the population means. In both tests of the population means, the null hypothesis could not be rejected and thus it was concluded that the mean warranty repair cost of Air Force automobiles was not significantly greater than the mean warranty repair cost of civilian-purchased automobiles. In short, the researchers were not able to statistically support their research hypothesis.

Analysis

As is typically the case when research fails to prove a hypothesis, it is incumbent on the researchers to suggest reasons for the unexpected outcome. In this particular study, the outcome was so far removed from what was expected, the conclusions suggested seem as though they should have been self evident from the beginning. It was genuinely believed prior to the research that the Air Force's average warranty repair cost would be <u>much</u> higher than the related figure for the civilian sector—much higher,* that is, than the approximately $13 difference actually computed. From the researchers' viewpoint, therefore, even if the confidence in the two average warranty repair costs ($45.10 and $31.71 respectively) could have been increased by deriving them from much larger samples, the outcome while undoubtedly reflecting reality, would have been suprising.

This research was hampered to a considerable degree by the unavailability of data. The data for both Air Force and civilian warranty claims do in most cases exist, but is impossible to obtain (aside from what could be acquired

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*A higher <u>average</u> warranty repair cost suggests that smaller, less costly, and perhaps less significant items are being repaired less often than in the case where a lower average warranty repair cost prevails.

There was one characteristic of the collected data that did prove to follow the anticipations of the researchers. The prior belief that the Air Force took less advantage of automobile warranties than the civilian sector was partially based on the presumption that the Air Force did not as often return automobiles for repair of nonfunctional or cosmetic malfunctions/discrepancies. Items in these categories would include paint blemishes, imperfections in the upholstery, distracting noises—in short, those items not likely to cause serious problems with vehicle operation. But because of the rather sketchy description of the repairs on the work orders possessed by both the Air Force and the dealers, it was not always possible to classify a repair as being in these categories. To indicate for instance that an "interior light" was replaced, may have referred to either a relatively important dash light or a simple nice-to-have dome light. In spite of this difficulty to categorize repairs, the general trend did seem to indicate fewer of the non-functional or cosmetic repairs on Government automobiles than on civilian-purchased automobiles.

from local dealers)—partly because of incomplete Air Force records and a refusal to release information on the part of the automotive industry. The process of tracking what warranty repairs were made on the fleet of Air Force automobiles at WPAFB was an arduous task requiring many hours of sorting through files of paperwork. When a record of a repair for a particular automobile was found, it was necessary to obtain the cost information associated with that repair from the dealer who accomplished the work. The Air Force record on file was in most cases a work order submitted to the dealer from the motor pool, and frequently was missing the exact nature, the servicing dealer, and often even the date of the repair. In no case did the work orders indicate the cost of the repairs. If the date and servicing dealer were recorded on the Air Force work order, the ability to get the specific cost associated with a repair was dependent on the dealer releasing the information from his files. In most cases, the dealers were very cooperative. But because the size of the Air Force automobile sample was diminished during the cost tracking process (i.e., missing information in Air Force and dealer files resulting in unusable data), the dealers were asked to furnish their 1976 warranty claim information for <u>all</u> Government automobiles. As has already been discussed, Government automobiles were thus used to represent all Air Force automobiles.

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

Several conclusions were reached and observations made in the course of this research. The research hypothesis was not supported, and the first issue that thus seems logical to address is what, therefore, is suggested about the Air Force's use of automobile warranties. The first part of this chapter concerns that subject. In addition, during data collection sessions, the researchers were able to evaluate the Air Force's automobile repair record keeping system. The inability to extract timely and accurate warranty repair information based on that system is discussed. Following, conclusions are presented concerning the benefits the Air Force derives from the standard commercial warranty it obtains with its automobiles. The chapter concludes with recommendations concerning the automobile warranty program.

The Air Force's Use of Automobile Warranties

The personnel in charge of automobile repairs at WPAFB seemed very knowledgeable of the Air Force regulations governing warranty repairs and professed to be totally committed to following those regulations explicitly. In discussions with motor pool employees, the impression was given

that when an automobile was in need of a warranty repair, there would be no question that such a repair would be sought from the dealers. While it was evident that maximum warranty use was seen as an important subject by WPAFB employees, it was disclosed in discussion with them that the Air Force Inspector General teams had not scrutinized this area in the past to any real degree.

Although automobile warranties seem to be well understood and generally utilized at WPAFB, there were certain attitudes and points-of-view expressed by Air Force personnel that may indeed indicate a difference in the way warranties are applied in the Air Force as opposed to the civilian sector. Having an automobile sent for repair to a servicing dealer was described by motor pool employees as having the ability to jeopardize an essential mission to be performed by that vehicle. That problem can be compounded by the fact that dealers have sometimes delayed fixing an Air Force vehicle in lieu of a privately owned vehicle. In addition, the delivery and pickup of a vehicle to the dealer means taking two people away from other duties. Regarding the importance of keeping an automobile in good shape for top value at disposal, the general concensus seemed to be that while operating condition was important, the concern for cosmetic and non-functional items was minimal.

As a general conclusion, it appears that the Air Force employees directly concerned with automobile upkeep are being as diligent as they feel is required regarding warranty repairs. The motivation these individuals seemingly respond to regarding warranty use, however, are Air Force regulations and the possibility of inspections by evaluation teams.

The Air Force Automobile Repair Record Keeping System

It is the researchers' conclusion that the Air Force does not accurately maintain records of warranty repairs accomplished on its automobiles. It was anticipated prior to the research that records would exist for each automobile indicating the vehicle's repair history including repairs performed by servicing dealers. No such accurate records exist. The record keeping system that <u>is</u> employed at WPAFB can be described as follows: For each automobile in service a repair card (AF Form 271)* is maintained that is annotated whenever a repair is made. Only a general description of the repair by code is made, and no specific designation is made for warranty repairs accomplished by servicing dealers. Since the date and mileage of the vehicle at the time of each repair is annotated, however, repairs during the first

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*This card is destroyed when a vehicle is removed from service.

12 months or 12,000 miles can be further investigated to see if they were in fact performed under warranty. To find that information, it was necessary to examine a file drawer of individual folders kept on each automobile. There is a folder for every automobile that was in operation at WPAFB. Contained in each folder is correspondence regarding the automobile work orders on repairs done in-house, and work orders on warranty work performed by servicing dealers. The folders for every automobile operated at WPAFB were examined. Many of the warranty work orders found had no date, no exact description of the repair, no cost information, and no identification of the servicing dealer. In the vast majority of folders no warranty work orders were found—suggesting that either the work orders were not being kept or that no warranty repairs had been done on the automobiles. Supporting the conclusion that the base fails to keep all applicable warranty work orders is the fact that the researchers found several records of repair on WPAFB vehicles in the files of the servicing dealers—with no related records on file at the base. It must be added that the sketchy completion of the warranty work orders that were found at the base is not the singular fault of the Air Force. The servicing dealers fill out the work orders at the time of the repair and the base motor pool files them away exactly as received.

The researchers conclude that the Air Force is in no position to precisely state what its automobile warranty repair experience has been. The lack of accurate historical records makes an analysis of Air Force warranty usage very difficult.

Benefits of Commercial Automobile Warranties to the Air Force

The researchers conclude that the Air Force has been acting under the belief that its automobile warranties are being satisfactorily utilized and no requirement to document or support that fact has been levied. It is the feeling of many transportation officials at Air Force Logistics Command Headquarters and Warner-Robbins Air Logistics Center that warranties are provided by the manufacturers without cost, and the question, therefore, of whether or not the Air Force is getting its money's worth is mute. In an alarmingly inflationary period in our history, this seemingly nonchalant attitude is puzzeling. The automobile warranty stands ready to insure for at least a year or 12,000 miles that the Air Force automobile fleet is in top condition with no monetary outlay by the Government. To the researchers, it would seem totally in line with all other Air Force cost-cutting ventures to insure that automobile warranties are being used to the maximum extent possible.

Recommendations

Since the repair of Air Force automobiles during their warranty period has the potential for being very expensive, the Air Force should take steps to insure that automobile manufacturers take responsibility for assuming all costs for which they are liable. For the Air Force to accurately monitor its warranty usage, it is recommended that it keep stricter account of warranty repairs performed by servicing dealers. When a dealer repair is made, the exact nature of the repair, the date, and the cost should be recorded. If the dealers are reluctant to provide exact cost figures, cost estimates should be calculated using standard repair cost manuals.

There are several reasons for the Air Force to record accurate warranty data. First, a base by base comparison of the warranty repair claims may uncover installations where warranty use should be emphasized to a greater degree. Secondly, exacting requirements to record each warranty repair would seem likely to encourage base employees to opt for dealer repairs rather than performing the repairs in-house or ignoring the problem altogether. This assumes, of course, that base employees are encouraged by the Air Force to seek dealer repairs whenever a warrantied malfunction is discovered. In addition, the Air Force would

be able to state more accurately what its automobile warranties actually prove to be worth, and the Government would therefore be in a more enviable position when contracting for more automobiles. Lastly, by having comparative warranty figures for different makes of automobiles, the Government could identify those with higher probability of repair.

The uses for accurate Air Force records as described above, would require that each base's data be fed to the Warner-Robins Air Logistics Center for consolidation and analysis. The existing Vehicle Inventory Management System (VIMS) already supplies other data on in-service Air Force automobiles to Warner-Robins and should be quite capable of including warranty repair information.

In the civilian sector, the careful upkeep of an automobile seems to be motivated by two primary factors: one, to prevent further deterioration and thus prolong the useful life of the automobile; and two, to insure top-dollar for the automobile at trade-in or selling time. The Air Force, in operating its automobile fleet, seems concerned with the economics of the first factor (prolonging the vehicle life), but considering the manner in which its automobiles are disposed of, little importance seems to be placed on maximizing the money its retired automobiles return to the Government. By auctioning its retired

automobiles through the Defense Property Disposal System, it seems unlikely that the Air Force is recovering maximum value.

Implicit in the attempt by the civilian sector to maximize the warranty provisions of its automobiles, is the ability to recover a better return for the vehicle at selling time. Acknowledging that it would require a major feasibility study of its own, it is recommended that the Air Force investigate the possibility of selling its automobiles in a way that would bring a return <u>closer</u> to their retail value. If its automobiles have been properly cared for (which includes maximizing their warranty use) it does not seem reasonable for the Government to take a discounted return when a higher one may be possible.

Both recommendations presented above certainly require further research before being seriously considered for implementation. A basic question that must be answered by top-level Air Force transportation managers is whether or not the use of automobile warranties deserves the scrutiny that the researchers believe that it should. It does seem likely that the question has, in fact, already been considered, and that the current seemingly passive attitude toward warranty use record keeping is a result of a decision that a more stringent system would not be of value. The researchers hope, however, that this is not the case, and that their recommendations be carefully analyzed for economic value.

APPENDIX A

ADDRESSES OF THE MANUFACTURERS' DISTRICT SERVICE OFFICES IN CINCINNATI, OHIO (12:11-27)

District Service Manager
Ford Motor Company
P.O. Box 1504
Cincinnati, Ohio 45215

Zone Service Manager
Chevrolet Motor Division
General Motors Corporation
11575 Reading Road
Cincinnati, Ohio 45241

Service and Parts Sales Division
Chrysler Corporation
P.O. Box 41902
Cincinnati, Ohio 45241

Zone Office
American Motors Corporation
1125 Glendale-Milford Road
Cincinnati, Ohio 45215

APPENDIX B

ADDRESSES OF PRIVATE ASSOCIATIONS (5)

American Automobile Association
8111 Gatehouse Road
Falls Church, Virginia 22042

Automotive Service Councils of America
4001 Warren Boulevard
Hillside, Illinois 60162

Car and Truck Renting and Leasing Association
1725 K Street, N.W.
Washington, D.C. 20006

Motor Vehicle Manufacturers
Association of the U.S.
328 New Center Building
Detroit, Michigan 48202

National Association of Fleet Administrators
60 East 42nd Street
New York, New York 10017

Independent Automotive Damage
Appraisers Association
B-15 First National Bank Building
Longview, Texas 75601

Automotive Information Council
666 Fifth Avenue, 6th Floor
New York, New York 10019

Center for the Study of Responsible Law
P.O. Box 19367
Washington, D.C. 20036

American Automotive Leasing Association
6815 West Capital Drive
Milwaukee, Wisconsin 53216

Automotive Market Research Council
Inland Steel
30 West Monroe
Chicago, Illinois 60603

National Institute for Automotive
Service Excellence
1825 K Street N.W.
Suite 1205
Washington, D.C. 20006

Automotive Service Industry Association
230 North Michigan Avenue
Chicago, Illinois 60601

APPENDIX C

ADDRESSES OF GOVERNMENT AGENCIES

National Highway Traffic Safety
Administration
400 Seventh Street S.W.
Washington, D.C. 20590

U.S. Department of Transportation
Special Assistant for Information Policy
Washington, D.C. 20590

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Gross, Captain Paul W., USAF. Research Associate, Air Force Business Research Management Center, HQ USAF, Wright-Patterson AFB, OH. Personal interviews conducted intermittently from 4 October 1976 to 15 November 1976.